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Low Temperature Physics Group

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Research Activities

I. Phase-separation kinetics of superfluid ^{3}He-^{4}He mixtures

(i) Critical supersaturation

(E. Tanaka, S. Noma, K. Hatakeyama and T. Satoh)

We have accumulated the data of critical supersaturation, $\Delta X_{3,cr}$, up to 600mK in temperature and up to 10atm in pressure. The anomalous behavior of the critical supersaturation is that it increases with the increase of temperature above about 10mK. By performing the experiment up to 600mK, we found that it starts decreasing above about 500mK. The result suggests that we are in the classical regime of nucleation in that high temperature region.

By refering to the result of sound experiment (see (ii)), the temperature region of 10mK$\leq$T$\leq$500mK is considered as a quantum regime with dissipations. A theoretical investigation is now in progress.

(ii) Dynamical property of the interface of phase-separated ^{3}He-^{4}He liquid mixtures

(H. Abe, M. Nakazawa, G. A. Sheshin and T. Satoh)

Since Lifshitz and Kagan, the standard model of macroscopic quantum nucleation (MQN) is to apply quantum mechanics to a macroscopic variable R, the radius of c-phase spherical nucleus and consider the motion of the interface between the c-and d-phases. Therefore, for the deeper understanding of MQN, it is very important to study the dynamical aspect of the interface.

In order to examine the kinetic properties of the interface, we take a way of the normal injection of sound wave (10MHz) onto the interface. With a special arrangement of sound cells, we succeeded to measure the transmission coefficient through the interface. From the data, we obtain the kinetic growth coefficient of interface, ξ_ω. We found that ξ_ω starts increasing with the decrease of temperature below about 70mK, and the temperature dependence is roughly $1/T^2$ down to 7mK, the lowest temperature of the present study. The magnitude and the temperature dependence of the observed ξ_ω can not be explained with a hydrodynamic theory. It seems necessary to take into account some ballistic processes even at 10MHz.

II. Spin-polarized quantum liquids

(S. Morita and T. Satoh)

In order to realize a highly polarized state of liquid ^{3}He, we are trying to develop a new method by using a ^{4}He-circulating dilution refrigerator. Our aim is to realize the polarization of 40 % as a stationary state with a magnetic field of 6 Tesla.

III. NEW COHERENT BILAYER QUANTUM HALL STATES

(A. Sawada, A. Urayama, N. Kumada)

We measured the Hall-plateau width and the activation energy in the typical bilayer quantum Hall (BQH) states at filling factor $\nu = 1$ and 2 by changing the total electron density as well as the density ratio. The stability of the QH states are found remarkably different from one to another. The $\nu = 1$ state is stable over all measured range of the density difference and has the minimum stability at the equal density ratio. The $\nu = 2$ state shows an unexpected phase transition between these two types of the states as the electron density is changed. The $\nu = 2$ state for the larger density is stable only around the balanced point, and that for the lower density is stable over all range of the density difference similarly to the $\nu = 1$ state.

IV. Bilayer $\nu = 2$ Quantum HALL State in Parallel High Magnetic Field
(A. Sawada, N. Kumada and S. Nagahama)

By tilting the sample as well as by varying density difference between the two layers, we have measured the activation energy of a bilayer quantum Hall state as a function of the total magnetic field. Let Θ be the tilt angle. When the densities are balanced, the activation energy begins to increase linearly beyond a certain critical angle Θ^* as the total magnetic field increases. The slope of the curve is $5.6|g^*|\mu_B$, from which we conclude that a skyrmion pair with spin 5.6 is excited. On the other hand, as the density difference increases, the activation energy decreases rapidly and eventually disappears. These results imply that the bilayer QH state is not a coherent state but rather a compound state beyond the critical angle ($\Theta > \Theta^*$).

V. Doubly Enhanced Skyrmions in $\nu = 2$ Bilayer Quantum Hall States
(N. Kumada, A. Sawada, S. Nagahama, H. Azuhata)

By tilting the samples in the magnetic field, we measured and compared the Skyrmion excitations in the bilayer quantum Hall (QH) state at the Landau-level filling factor $\nu = 2$ and in the monolayer QH state at $\nu = 1$. The observed number of flipped spins is $N_s = 14$ in the bilayer system with a large tunneling gap, and $N_s = 7$ in the bilayer system with a small tunneling gap, while it is $N_s = 7$ in the monolayer system. The difference is interpreted due to the interlayer exchange interaction. Moreover, we have observed seemingly preferred numbers $N_s = 14, 7, 1$ for the flipped spins by tilting bilayer samples.

VI. Interlayer charge transfer in bilayer quantum Hall states at various filling factors
(N. Kumada, A. Sawada)

We have studied bilayer QH effects in double-quantum-well structures at various Landau-level filling factors ν. The stability of various QH states are examined by varying the density balance between the two layers. We observe a remarkable ν-dependent behavior; the interlayer charge transfer is allowed for particular values of ν, which then repeat in a characteristic sequence with a period of 4. We employ a pseudospin picture, by which the interlayer charge transfer is expressed as a rotation of the total pseudospin. The ability or inability to accommodate the charge transfer represent the degree of pseudospin polarization in the bilayer QH state.

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Master Thesis (March 1999)

M1) Excitation Energy in Bilayer Quantum Hall States. (N. Kumada)

M2) BBP Parameter: Dependence on Temperature, Pressure and the ^{3}He-concentiation. (S. Noma)

M3) Ultrasonic study of ^{3}He-^{4}He liquid mixtures. (M. Nakazawa)